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DEFEATING THE UNITED STATES WITH RADIOLOGICAL WEAPONS IN FOURTH GENERATION WARFARE

by

Julian M. Chesnutt, Major, USAF

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Advisor: Dr Donald A. MacCuish

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Preface

The September 11th attacks forced the United States to think differently about the nature of our enemies specifically and the nature of war in general. A few prescient thinkers foresaw these changes in 1989 when they penned the article "The Changing Face of War: Into the Fourth Generation." The article described how soldiers organized into small cells and operating under mission type orders, would conduct operations targeted primarily against the *will* of the enemy. The goal of these "fourth generation warfare" (4GW) operations would be to use the strength of the enemy against himself to cause a "collapse from within."

I chose explore how an adversary may apply the principles of 4GW to not only attack, but defeat, the United States; much as the Air Corps Tactical School officers wargamed "how to defeat the United States" prior to WWII. I chose to focus on radiological weapons as the 4GW tool of choice because they are relatively new and often misunderstood additions to the WMD arsenal. Although a fighter pilot by trade, I studied physics at the graduate and undergraduate levels, and I found "radiation" interesting in that it universally evokes anxiety. This was evident in my fellow students' faces upon being issued dosimeters before entering the "Rad Lab" for the first time. Lastly, I think the probability of a radiological attack is exceedingly high due to the availability of radioactive material and the determination of our adversaries. Our enemies, such as Al-Qaeda, operate under the philosophy espoused by Arnold Swarzenegger in the movie Predator … "if it bleeds, we can kill it," and after September 11th, they have tasted blood.

Of note, I will not specifically address the threat posed from nuclear weapons in this paper, although many of the same concerns apply.

Abstract

On September 11th 2001, Al-Qaeda used the principles of fourth generation warfare (4GW) to achieve strategic effects that have cascaded throughout the United States. The devastating attacks could have been multiplied a hundred fold or more had each of the hijackers checked two bags each containing radioactive material. This paper addresses the possibility of a 4GW adversary launching a parallel radiological attack targeting the US economic system. An attempt will be made to determine if the effects of such an attack could strategically paralyze the US economy to the extent that the American way of life is significantly changed--a de facto "defeat of the United States."

The methodology of the investigation will use the center of gravity analysis posed by Dr. Joe Strange coupled with Brig Gen David Deptula's effects-based operations model. In order to draw the conclusion, several historical examples will be extrapolated from in addition to an analysis of the likelihood of a 4GW adversary acquiring sufficient radioactive material to carry out a successful attack. Since September 11th 2001, the US government has trained its attention on terrorism and WMDs. The relevancy for understanding the principles of 4GW, radiological weapons, their effects, and the threats they pose has never been more urgent.

Part 1

Background

The economic impact that could result from such an attack could be devastating

—Senator Joseph R. Biden, Jr

Introduction

Overwhelming economic and military might has propelled the United States to "hyperpower" status, dwarfing the nearest competitor in terms of hard and soft power.[1] US military supremacy is maintained by a well-proportioned combination of funding, technology and training that allows engagement throughout the spectrum of conflict. The $400 billion 2004 US defense budget is larger than the next 20 countries combined, spending more on defense than the sum of the remainder of the NATO alliance.[2] The $11 trillion US economy is a juggernaut, five times as large as the nearest competitor and accounting for nearly 30 percent of world's gross domestic product.[3] This vast military and economic hegemony did not deter our adversaries from *attack*, leading to the question if the United States is immune from *defeat.*

The September 11th attacks proved to be a victory for an asymmetric foe, Al-Qaeda, using the principles of fourth generation warfare (4GW) to achieve strategic effects that have cascaded throughout the United States. As severe as the aftereffects of the September 11th attacks were, they could have been far worse. Al-Qaeda's attacks were a stunningly successful example of the principles of 4GW. The attacks cost Al-Qaeda roughly $500,000 to orchestrate, while causing

over $100 billion dollars in damage—achieving an astonishing 200,000 percent "return on investment" for the terrorists.[4] Had each of the hijackers checked two bags each containing radioactive material such as cesium-137, the airliners would have been converted into flying radiological weapons. The resulting explosion would have contaminated downtown Manhattan with radioactive fallout, making it uninhabitable for decades, centuries, or theoretically, a millennium. The permanent "loss" of downtown Manhattan would have pushed the cost of the attack into the trillions of dollars, highlighting the unique ability of radiological weapons to cause severe economic damage through disruption and area denial, in addition to psychosocial impacts caused by fear and trepidation.

Radiological weapons, colloquially known as the "dirty bombs," are the newest Weapons of Mass Destruction (WMDs) to garner public attention. In fact, the common acronym, NBC, for Nuclear, Biological, and Chemical, did not even address "Radiological" weapons. The United States and Russia are concerned about the threats posed by radiological weapons, and have been quietly testing the devices.[5] The tests are most likely concentrating on the effects on a civilian population and urban areas, since such weapons have very little battlefield utility. In fact, only Iraq has attempted to develop a radiological weapon for battlefield use, the Nasser 28, a project that was abandoned in the 1990s.[6]

No foe can mount a serious challenge conventionally to the US military. While the US military certainly contains "critical vulnerabilities," especially to 4GW, sustained successful attacks on those vulnerabilities to achieve a strategic military victory remain problematic for any potential adversary. Quite the opposite situation exists in regards to US economic might. The core center of gravity of the American way of life is our burgeoning economy. Our economy

fuels the high standard of living, the cherished convenience culture, the military, and our global engagement policies.

Thesis

Could a coordinated radiological attack, drawing upon the principles of fourth generation warfare, cause strategic paralysis in the economy, resulting in a "de facto" defeat of the United States? How plausible is such an attack, and what are the necessary constituents to carry it out? Are there any precedents for such an event?

Unfortunately, the US economy is astonishingly vulnerable to 4GW … and radiological weapons are ideally suited to achieve the strategic effects necessary to cripple the United States via the "soft underbelly" of American power—its economic strength. Analyzing the plausibility of a radiological attack is relatively straightforward. However, analyzing the effects of a coordinated radiological attack is far more speculative because of three overarching reasons. First, the effects of radioactivity are contingent on multiple factors, of which experts and agencies frequently disagree. Second, the US economy is the ultimate systems of systems, and predicting its course is extremely challenging even without the occurrence of catastrophic events. Finally, predicting the magnitude of the psychological impact of a radiological attack is problematic due to the complexity and variety of human reaction to traumatic events. Accurately investigating these questions and the thesis in general requires a methodical approach.

Methodology

The most logical methodology is to first determine if a coordinated radiological attack is plausible and then if it could cause strategic economic paralysis. The necessary constituents and conditions for an economically crippling radiological attack are the following: radiological

material, dispersal material or medium, appropriately trained actors, center of gravity analysis of US economic system, exploitable target vulnerabilities and a medium to propagate the long-term effects of the attack. Each of these constituents will be examined. The final analysis extrapolates from both the terror attacks of September 11th and radiological accidents in Brazil, the United States, and the USSR as well as other recent events that induced substantial disruption, fear and panic out of proportion to the threat actually posed. Of note, before radiological weapons are analyzed, a primer on radioactivity will be offered. Understanding the nature and nomenclature pertaining to radioactivity is vital to the analysis of whether a coordinated radiological attack would be effective in producing sufficient disruption and fear to paralyze the economy. The final thesis analysis will be via a fictitious scenario for a parallel radiological attack. The principles of 4GW underlie most of the elements of a radiological attack and must be discussed before an appropriate contextual assessment of the thesis can conducted.

Principles of Fourth Generation Warfare

"Fourth generation warfare is here," having made a bold appearance with the destruction of the twin towers.[7] However, the shift to 4GW is a product of the changes in the political, cultural, informational and economic systems of the 21st century and did not occur suddenly on the eve of September 11th, 2001. The genealogy of modern warfare has passed through three distinct generations. The first generation concentrated on linear tactics—movements of troops in lines and columns.[8] Second generation warfare incorporated maneuver tactics and indirect fire, while the development of non-linear tactics and combined arms ushered in the third generation of warfare—the generation the US military still follows in the majority of its operations.[9] Political, social and economic factors have coalesced to drive a fourth generational change.[10] As the generations of warfare progressed, the battlefield expanded into

civilian society, thus thwarting the thin veil of protections normally afforded to noncombatants. The expansion of warfare into civilian society facilitates the fourth generation warrior's goal of collapsing the enemy internally--a marked changed from the wars of attrition and annihilation familiar to most western militaries.[11]

Fourth generation warriors will likely operate under mission-type orders, deploy in small groups, and be outfitted with high-technology weapons.[12] The leaders of these fourth generation warriors will be well versed in psychological operations and knowledgeable of the principles of warfare. The tactics employed will be irregular and asymmetric, attempting to bypass American military strength and target the will of the people, a methodology that fits Al-Qaeda perfectly.[13] The September 11th attacks exemplified the 4GW principle of a shift from fighting the enemy's military to attacking its population. This idea is not new, in fact, Giulio Douhet propose that the most effective path to victory is to instill fear by attacking the defenseless civilian population of your enemy.[14]

Another key principle of 4GW involves using the enemy's strength against him.[15] This central tenet of 4GW draws from the concept espoused in Judo that concentrates on using an enemy's strength and momentum against himself.[16] Because of the overwhelming power of the United States, the potential that even a portion of that strength being redirected against itself could cause immense harm. As an example, the September 11th hijackers took advantage of our open society and convenience culture to enter the country, receive flight training, rent apartments, obtain airline tickets, and board the aircraft. The terrorist even took advantage of the nature of the flight crew, most likely surmising the easiest way to get at least one of the pilots out of the cockpit was to endanger the flight attendants—a strategy that apparently succeeded.

The success of a 4GW attack using radiological weapons would also hinge on the nature of the American people and the culture in which they reside. Groups employing 4GW tactics would cherish inflicting a mortal wound on the United States by using a parallel radiological attack, but before such and attack could be carried out, the necessary constituents must be ascertained and assembled.

Attack Constituents

Successful implementation of the 4GW strategy to stymie the US economy begins with the will to carry out such an attack. Once the will is established, the adversary must acquire the requisite materials and fashion the radiological weapons. The key constituent, however, is the center of gravity analysis. If done with skill and cunning, the center of gravity analysis will guide the 4GW adversary to the appropriate targets that will lead to crippling the US economy. Finally, the foe must infiltrate into the target area and activate the radiological weapon. Once activated, the effects of the radiological weapons will be amplified by the very nature of the enemy and society. The attack, if successful, would exploit the central tenets of 4GW … "using the enemy against itself" and to "collapse the enemy from within."[17]

The global terrorist organization Al-Qaeda has demonstrated the will to carry out such an attack. Before September 11th, the most experts assumed that an enemy would not use radiological weapons because the death or injury to the adversary is very likely. This changed when an Al-Qaeda foot soldier, Jose Padillo, admitted to plans of a dirty bomb attack.[18] Now, it is clear that 4GW foes are willing to give their lives in furtherance of their goals.[19] No further analysis of motive or will is provided, in short, both are taken as "givens." Will, however, is not enough; the adversary must possess the means to acquire the radiological weapons.

The key component in fashioning a radiological weapon is obtaining the requisite amount of radiological material. Radiological material is frighteningly easy to acquire, with many sources within reach of even a moderately determined foe. An investigation into the probability of obtaining this material is presented in Part 3 of this paper. The expertise required to safely handle radioactive material could be obtained from attending hazardous material courses sponsored by government, universities and industry. A number of agencies, such as the Nuclear Regulatory Commission, Department of Environmental Health and Safety and the Health Physics Society, publish manuals on handling radioactive materials. Access to these manuals is uncontrolled. Compared to fabricating a nuclear weapon, the skill required for a radiological weapon is simplistic.

Once the radiological weapon is procured, the adversary must then identify the centers of gravity; this step can, of course, be accomplished before procurement of the radiological weapons. Once the centers of gravity are identified, then the critical capabilities, critical requirements, and critical vulnerabilities must be discerned and targeted. The 4GW foe must accomplish an analysis of the likely *physical*, *systemic* and *psychological effects* of the attack by applying effects-based operations methodology.[20] A cursory center of gravity analysis of the US economy is given in Part 4 of this paper.

Once the targets are chosen, the weapons must then be infiltrated into the area and activated. A 4GW adversary will use the nature of radioactivity and the fear of its medical effects to achieve strategic paralysis. The nature of radioactivity is vital to the success of the attack. Before a proper analysis of the thesis can be rendered, a clear understanding of the "active ingredient" of radiological weapons must be explained along with its effects on humans.

Notes

[1] Quoted in Christopher Layne, "Offshore Balancing Revisited," in *The Washington Post Quarterly,* Spring 2002, 239.

[2] Christopher Hellman, "Fiscal Year 2004 Budget, Center *for Defense Information,* 19 March 2003, 1-2, on-line, Internet, 4 April 2003, available from http://www.cdi.org/budget/2004/world-military-spending.cfm.

[3] *Comparative Real Gross Domestic Product,* US Government (Washington, D.C.: US Department of Labor, March 2000), 8-10.

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[5] Charles J. Hanley, "US, Russian Experts Quietly Testing Dirty Bombs in Growing Effort to Combat Terror Threat," *Associated Press*, 15 march 2003, 1-2, on-line, Internet, 25 March 2003, available from http://lexis-nexis.com/universe/document?m=do31ca78a7d3e9f0039ba14ea66 13bf2&_docnum=10.

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[7] Harold A. Gould and Franklin C. Spinney, "Fourth-Generation Warfare Is Here," *Defense in the National Interest*, 15 October 2001, n.p., on-line, Internet, 1 April 2003, available from http://www.dni.net/fcs/gould_spinney_4GW.htm.

[8] Col William S. Lind et al., "The Changing Face of War: Into the Fourth Generation," *Marine Corps Gazette,* October 1989, 23.

[9] Ibid., 24.

[10] Lt Col Thomas X. Hammes, "The Evolution of War: The Fourth Generation," *Marine Corps Gazette,* September 1994, 1, on-line, Internet, 25 March 2003, available from http://www.d-n-i.net/fcs/hammes.htm.

[11] Lind et al., 23.

[12] Ibid., 24-25.

[13] Jason Vest, "Fourth Generation Warfare," *The Atlantic Monthly* 288, no. 5 (December 2001): 14-15.

[14] Giulio Douhet, *Command of the Air,* Trans. Dino Ferrari (Washington, D.C.: Coward-McCann, 1942), 126.

[15] Wilcox, 4.

[16] Ibid., 25.

[17] Lind et al., 23-24.

[18] Louis Charbonneau, "IAEA Director Warns of Dirty Bomb Risk," *Reuters,* 12 March 2003, A15, on-line, Internet, 12 March 2003, available from http://www.washingtonpost.com/wp-dyn/ articles/A12629-2003Mar11.html.

[19] Senate, *Dirty Bombs and Basement Nukes: the Terrorist Nuclear Threat: Hearings before the Committee on Foreign Relations,* 107th Cong., 2d sess., 2002, 2-3.

[20] Jay M. Kreighbaum, "Force Application Planning: A System-and-Effects-Based Approach" (master's thesis, School of Advanced Airpower Studies, 1998), 55-67.

Part 2

Radioactivity and Its Medical Effects

Radioactivity can be described in cold, scientific terms, but like no other aspect of nuclear energy, it evokes feelings of fear and apprehension. That the effects of radioactivity are delivered by stealthy, invisible, silent forces only intensifies these feelings.

--Dr. Walter Scheider
Professor of Physics, University of Michigan

Radioactivity

The radioactivity associated with the materials used in radiological weapons is a type of *ionizing radiation*. To ionize an atom is simply to knock off or strip an electron from its atomic orbit. With the loss of one or more electrons, the atom's chemical properties change. In living organisms, this chemical change may kill the cell or cause a mutation in its progeny. Without ionizing radiation, a radiological explosive device is simply another bomb; and radiological dispersion device would be harmless. Essentially, radioactivity results when a nucleus of an atom breaks apart, or *disassociates*, and some of the parts fly off at high speed. The parts that fly off are the Alpha, Beta and the Gamma particles.

Radiation

The Alpha particles are the heaviest and move at relatively slow speeds.[1] Alpha particles can be stopped by a sheet of paper,[2] but are the most damaging to living tissue.[3] The larger size

of the Alpha particle makes it more likely to hit something critical, like deoxyribonucleic acid (DNA) of a cell. The Beta particle is millions of times smaller than the Alpha and can be stopped by a mere millimeter of metal—about the shielding of a can of soda pop.[4] The Gamma particle, or more correctly, Gamma ray, is a high-energy "packet of light" and therefore has no quantifiable mass.[5] Because of its high energy and lack of electric charge, the Gamma ray can penetrate up to a centimeter of lead.[6] .

Radioactive Half-Life

Another inevitable term cogent to radioactivity, that is often misapplied, is half-life. The half-life is the "average time interval required for one-half of any quantity of radioactive atoms to undergo radioactive decay."[7] A common misperception is that if you wait two half-lives, and then the radioactive substance will no longer be harmful because all the nuclei will have disassociated or "decayed."[8] This is false, and a good method for explaining the falsehood is the analogy adapted from Dr. Walter Scheider given below:

> Suppose a group of 32 first graders go to a baseball game. Each child is given a baseball cap. The following day, all the children appear in school wearing their hats. First graders tend to lose things like hats, and the statistics show that is likely that in the first two days, half the children will lose their hats. Therefore, after two days, only 16 children still have hats. Those who have lost their hats no longer play in this game; only those who still have hats. Statistics then predict that in the next two days, half of these 16 will lose their hats, and only 8 will still have their hats. In another two days, half of these 8 will lose their hats, and only 4 will still have hats. Two days later, only 2 will have hats and two more days later only 1 will have a hat. In the next two days, there is a 50% chance that this one will lose her hat.[9]

From this analogy, you can see that first graders' hats have a two day half-life, and starting with 32 hats, it takes 12 days, not 4, for there to be a reasonable chance that all the hats are lost. Applying the analogy to a radioactive source, it is evident that while half-life is very important, the amount of the material, the number of hats in the analogy, also dictates how long it will take

before there is a negligible amount of radioactive material. The half-life of a material is as important as toxicity to a fourth generation warrior because it is a key determinant in how long access is denied to the contaminated area. Even a small amount of a long half-life material may be enough to convince people to abandon an area for many decades or centuries. A table of radioactive materials and their half-lives shown below:

Table 1. Radioactive Isotopes and Their Half-lives

Element	*Symbol*	*Mass #*	*Radiation*	*Half Life*
Cobalt	**Co**	**60**	**Beta, Gamma**	**5.27 years**
Strontium	**Sr**	**90**	**Beta**	**28.8 years**
Cesium	**Cs**	**137**	**Beta**	**20 years**
Uranium	**Ur**	**238**	**Alpha, Gamma**	**4.5 billion years**
Plutonium	**Pu**	**239**	**Alpha, Gamma**	**24,100 years**
Americium	**Am**	**241**	**Alpha**	**432 years**
Radium	**Ra**	**226**	**Alpha, Gamma**	**1600 years**
Barium	**Ba**	**139**	**Beta**	**82 minutes**
Iodine	**I**	**131**	**Beta, Gamma**	**8 days**
Iridium	**Ir**	**192**	**Beta, Gamma**	**74 days**
Phosphorus	**K**	**32**	**Beta**	**14.29 days**
Carbon	**C**	**14**	**Beta**	**5700 years**
Radon	**Rn**	**222**	**Alpha**	**3.82 days**
Note: Shaded Entries Would Be Ideal Choices For Radiological Weapons				

Sources: Walter Scheider, *A Serious But Not Ponderous Book about Nuclear Energy* (Ann Arbor, Mich.: Cavendish Press, 2001), 164.[10]; and, Armed Forces Radiobiology Research Institute, *Medical Management of Radiological Casualties* (Bethesda, Md.: Military Medicine Operations Office, December 1999), 118-139.[11]

Radioactive Intensity

For living organisms, the danger posed by radioactive material is contingent on two factors: the intensity of the radioactivity and length of exposure. The intensity of radioactivity is measured in units called *Becquerels* or *Curies,* were a Curie equals 3.7 billion Becquerels. The number of disassociations occurring per second is the "intensity" or "radioactivity" of the source. The greater the number of disassociations, the more "radioactive" the source, and hence the more Alpha, Beta, and/or Gamma particles being emitted. The more particles emitted, the more likely they will hit something critical, like the DNA in a living cell. The intensity or radioactively is related to half-life, which is related to the amount of material (atoms) present. A good example of this relation, also adapted from Dr. Walter Scheider, is given below:

> How long would it take before 1,000,000 Curies of radioactive barium-139 and 1,000,000 Curies of radioactive cesium-137 to decay to the point that they were harmless to living organism? Barium-139 has a half-life of 82 minutes. In 82 minutes, its radioactivity is reduced to 500,000 Curies, in 164 minutes it is down to 250,000 Curies. In one day, it will be halved more than 17 times, and the radioactively will be down to 5 Curies. After three days, it will be harmless. The half-life of cesium-137 is 20 years. In 20 years, is radioactivity is reduced to 500,000 Curies; in 40 years it is down to 250,000 Curies. It will take 340 years before its radioactivity is down to 5 Curies. After 1000 years, it will be harmless. The question, of course, is this: if they both have the same starting radioactivity, what is it about cesium-137 that makes is so much more troublesome? The answer is that there is a lot more of it. Not more Curies, but more radioactive atoms to begin with. Cesium-137 is on a long schedule, which means that any given cesium atom is far less likely in the next 5 minutes to dissociate. This makes it clear that, since the half-life of the cesium is 130,000 times longer than that of the barium, it will require 130,000 times as much cesium. In this example, the starting amounts are 0.06 grams of Barium-139 and 7.9 kilograms of cesium-137.[12]

Of note, this is why long half-life radioactive materials such as cesium-137 and americium-241 would be ideal radiological weapons--less than 20 pounds could contaminate an area for nearly a thousand or 10,000 years, respectively. However, the fact that radioactive materials emit ionizing radiation is not in itself dangerous. For radiological weapons to evoke fear, the

radiation they emit must "hit" something, namely a living organism. The amount of times an object is "hit" by ionizing radiation is called *exposure*.

Radioactive Dose

Exposure has two subcategories. The *rate of exposure* is the amount of radiation that is received by an object per second.[13] The *cumulative exposure* or more commonly the *dose* is the total amount of radiation received or absorbed. A short exposure to a highly radioactive source could be as damaging as a long-term exposure to a mildly radioactive source. The international accepted unit of measure for absorbed dose is the *Grey*; however, many US texts use the unit *Rad*, where 100 Rads equals 1 Grey. A somewhat confusing unit is the Sievert, which measures equivalent dose. Equivalent dose is the absorbed dose in humans. The Sievert accounts for the different types of radiation and is calculated by multiplying the absorbed dose (Greys) by a qualifying factor. An equivalent dose unit often used in older or US literature is the *REM*, for *Roentgen Equivalent Man*. One Sievert is equal to 100 REMs. In a sense, a Sievert is not an exact unit because a 30-year-old man and a 60-year-old woman exposed to ten Sieverts may not manifest the same symptoms. Many texts and radiation safety charts use the units for absorbed dose, Grey, and equivalent dose, Sievert, interchangeably. This is done because radiation detectors can only measure Greys, which are later converted into Sieverts based on the other contextual factors, if known, such as type of radiation, body part(s) irradiated, type of source and length of exposure. Notably, there is potential for confusion when dealing with the amounts and types of radiation, and only a very small segment of the population understands the nature and importance of these differences. The general public's lack of knowledge of the most basic facets of radiation and its effects on humans will play into the hands of a 4GW foe. The effects of radiation on the humans range from predictable to extremely nebulous. Countless amounts of

research has been accomplished, unfortunately some without the knowledge of the participants, in order to determine the medical effects of radiation.[14] The effects of radiation exposure categorized into *immediate* and *delayed* while the sources are defined as *external* and *internal.*

Medical Effects of Ionization Radiation

External exposure occurs when the radioactive source is outside the body. An internal exposure occurs when the source is inside the body.[15] An internal source can enter the body through ingestion, inhalation or a break in the skin.[16] Immediate effects occur in months or less, while delayed effects manifest themselves in years. The immediate effects of ionizing radiation are shown in the table below:

Table 2. Immediate Medical Effects of Ionizing Radiation Exposure

Dose (Rad) Dose (Grey)	Biological Effect
< 5 Rad < .05 Grey	No immediate observable effects
5 - 50 Rad .05 - .5 Grey	Slight blood changes may be detected by medical evaluation
50 - 150 Rad .5 – 1.5 Grey	Slight blood changes will be noted and likely symptoms of ARS (nausea, fatigue, vomiting, etc)
150 - 1000 Rad 1.5 – 10 Grey	Severe blood changes will be noted and symptoms appear immediately. Approximately 2 weeks later, some of those exposed may die. At 300-500 Rad, up to one half of the people exposed will die within 30 days without intensive medical attention. Death is due to the destruction of the blood forming organs.
1000 - 2000 Rad 10 – 20 Grey	The probability of death increases to 100% within one to two weeks of receiving a 2000 Rad dose. The initial symptoms appear immediately. A few days later, things get very bad, very quickly since the gastrointestinal system is destroyed.
> 2000 Rad > 20 Grey	Death is a certainty. At doses above 5,000 Rad, the central nervous system (brain and muscles) can no longer control the body functions, including breathing and blood circulation. Everything happens very quickly. Death occurs within days or hours.

Source: "Radiation Safety," *Sandia National Laboratory*, n.p., on-line, Internet, 3 April 2003, available from http://www.sandia.gov/tp/SAFE-RAM/bio.htm.[17]

A delayed effect can occur when a cell's DNA has been damaged. When the cell divides, the damaged DNA is replicated and passed on to the future generations of the cell. If the blueprint for the control of cell reproduction is damaged, a likely result will be the production of a cancerous cell. This process takes time to manifest the pernicious results. As an example, the incidence of leukemia in the Hiroshima area peaked five to seven years after the atomic bomb was detonated.[18] Similarly, the peak in thyroid cancer of Chernobyl survivors occurred four to five years after the meltdown.[19] Birth defects can result in much the same manner a sperm or egg cell sustained radiation damage.[20] A table of the delayed effects of ionizing radiation is shown below:

Table 3. Delayed Medical Effects of Ionizing Radiation Exposure

Disease	*Minimum Latency Period*	*Relative Risk at 1 Grey*
Leukemia	2 years	4.9
Bone cancer	3 years	1.2
Thyroid cancer	5 years	1.2
Solid tumors	10 years	3.3

Note: Relative risk can be simplified and summarized as the increase in likelihood of contracting the disease, thus, a person exposed to 1 Grey of radiation is roughly five times more likely to contract Leukemia than a person only exposed to normal background radiation.

Sources: National Council on Radiation Protection and Measurements, *Management of Terrorist Events Involving Radioactive Material* (Bethesda, Md: NCRP, October 2001), 33-36.[21]; and Shigematsu, I., et al, eds. *Effects of A-Bomb Radiation on the Human Body* (Tokyo, Japan: Bunkodo, 1995), 16-28.[22]

The US governments recommended maximum permissible radiation exposure per year is 0.005 Sv (5 REMs).[23] As a point of reference for the extent of this exposure, one chest x-ray is

about 0.00005 Sv (0.005 REMs).[24] The most salient question that arises then is "how many Curies would a radiological weapons need to have to cause more Sieverts/REMs or Greys/Rads than is safely permissible?" Unfortunately, it is impossible know exactly, because intensity are "the number of shots fired" from the radioactive material while the equivalent dose is the number of "hits" on human tissue. It is theoretically possible, although statistically unfathomable; that a person could sleep inside the nuclear power plant's reactor chamber and not receive a single Sievert. However, an educated guess can be made from an incident discussed later in this text where a 1400-Curie source of cesium-137, approximately ten grams of radioactive material, killed four people. Each fatality absorbed between three and five Sieverts, while 244 others suffered from some degree of radiation sickness after absorbing one Sievert or less of radiation.[25]

The inherent confusion between radioactive intensity (measured in Curies or Becquerels), absorbed dose (measured in Greys or Rads) and equivalent dose (measured in Sieverts or REMs) will aid the 4GW foe by sowing the seeds of doubt concerning the amount of radiation actually present after a radiological attack. This uncertainty, coupled with the anxiety of suffering from the delayed effects of radiation, multiplies the fear generated by radiological weapons. Although radioactivity can pose a very substantial risk, radiological weapons prey upon the natural human aversion to radiation, perhaps hyperbolizing that risk to the point of paralyzing the public.

Notes

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[3] Walter Scheider, *A Serious But Not Ponderous Book about Nuclear Energy* (Ann Arbor, Mich.: Cavendish Press, 2001), 149.

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[7] Parker, 895.

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[9] Scheider, 153-154.

[10] Ibid., 164.

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[21] National Council on Radiation Protection and Measurements, *Management of Terrorist Events Involving Radioactive Material* (Bethesda, Md.: NCRP, October 2001), 33-36.

[22] I. Shigematsu et al., eds., *Effects of A-Bomb Radiation on the Human Body* (Tokyo: Bunkodo, 1995), 16-28.

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[25] Alex Neifert, "Case Study: Accidental Leakage of Cesium-137 in Goiania, Brazil, in 1987," 1996, 1-2, on-line, Internet, 2 April 2003, available from http://www.nbc-med.org/SiteContent/MedRef/OnlineRef/CaseStudies/csgoiania.html.

Part 3

Radiological Weapons

There is a fear of radiation, a fear of health effects… and of course the terrorists' greatest weapon is fear."

--Dr Richard A. Meserve
Chairman, Nuclear Regulatory Commission

Terminology

Radiological weapons consist of radioactive material and a dispersal mechanism. The most common nomenclature for a radiological weapon is a radioactive dispersal device, a *RDD*. A RDD uses conventional explosive to disperse the radioactive material is dubbed a radiological explosive device, a *RED*, or more commonly, the infamous "dirty bomb."

Dispersal Mechanisms

Explosive material is readily available and used commercially for blasting and mining operations. An adequate conventional explosive can be formulated using legal and unmonitored materials such as nitrogen fertilizer and diesel fuel. Sufficient explosive material can easily be obtained in the CONUS and is even more available overseas in failed states. The necessary expertise to fabricate the weapon could be garnered from limited military or paramilitary training. Textbooks or online sources provide the basics for fabricating explosive devices. The only moderately high hurdle in the device fabrication process is obtaining sufficient quantities of radioactive material. Perhaps a more insidious type of RDD uses non-explosive means to

disperse the radioactive material, such as water or air. Unlike a dirty bomb, these devices may emit radiation undetected for extended periods before their presence is detected.

Figure 1. Possible Simplistic Design for a Radiological Explosive Device

Radioactive Material

The International Atomic Energy Agency (IAEA) estimates "millions" of radioactive sources have been produced since the 1950s,[1] with over two million in the United States.[2] A substantial percentage of the "millions" of sources are "orphaned," meaning they were never subject to regulatory control, abandoned, lost or stolen.[3] The IAEA estimates that there are tens of thousands of orphaned sources worldwide and over 5,000 in the United States.[4] Criminal trafficking in radioactive sources is significant, with over 280 cases documented since 1993, and estimates that the number of undocumented cases could be ten times as large.[5]

The Mecca for orphaned sources is the Former Soviet Union (FSU). Over 100 sites exists in the FSU where significant radioactive material is stored, much of which is either unguarded, unsecured or under secured. The concern is that many of these sites contained *special nuclear material*, which is highly enriched uranium or plutonium—a.k.a. *weapon's grade nuclear* material. Theft of an actual nuclear weapon or fashioning an improvised nuclear device is possible; however, an adversary would need a great deal of expertise to fabricate a weapon or

the proper codes to detonate a stolen weapon. A more likely use for the 4GW adversary is using this material in the fabrication of a RDD. The extreme intensity and long half-life of uranium and plutonium would make for a physically and mentally devastating dirty bomb. Although weapon's grade uranium and plutonium are subject to close monitoring, other lower grade nuclear materials used in reactors and other commercial enterprises receive far less scrutiny. As an example, some 120 Russian nuclear submarines have been decommissioned and await dismantlement at Arctic or Far Eastern naval bases, most of which are only minimally secured. Some of these submarines are listing or have sunk in their mooring places with their nuclear reactors on board.[6] A determined fourth generation warrior could either infiltrate into such a facility and steal the nuclear fuel, or obtain it by bribing officials—a relatively common practice in the underpaid and disenfranchised FSU military.

Securing sources and preventing smuggling from Russia is a major challenge, hampered by the poor economic condition of the Russian military and the 12,500-mile border Russia shares with fourteen countries.[7] The following incident demonstrates how easily a 4GW foe could obtain highly toxic radioactive material. In 1998, three Greenpeace activists boarded a British cargo ship carrying spent reactor fuel to protest the environmental hazards the material posed.[8] The shipment, like many of such material, was insufficiently guarded. Had the Greenpeace activists been 4GW adversaries, they could have easily taken possession of enough radioactive material to build hundreds of dirty bombs. Although nuclear fuel poses an extreme hazard, other types of dangerous radioactive sources are even easier to obtain due to their widespread commercial use.

The radioactive sources most likely to be used in a radiological weapon are cesium-137, americium-241, cobalt-60, strontium-90 and iridium-192. All these materials have commercial

uses, sufficient radioactivity and a long half-life, and thus are ideal choices for the fourth generation warrior. Cesium-137 is used in industrial gauges, x-ray equipment and medical radiotherapy devices.[9] Chechen guerrillas used cesium-137 in a RDD in Moscow in 1995 as part of an ongoing terror campaign to dissuade Russian occupation of their homeland.[10] The February 2003 theft in Nigeria of industrial x-ray equipment contained enough cesium-137 to contaminate sixty city blocks … the material has thus far not been recovered.[11] Americium–241 is used in smoke detectors and exploratory oil drilling, and is considered the prime candidate material for a dirty bomb due to its toxicity and long half-life.[12] Cobalt-60 is widely used in medical radiotherapy devices and the ubiquitous food irradiators.[13] Eleven border guards in FSU Georgia were contaminated by a cobalt-60 source left in an abandoned warehouse in 1997 and abandoned source killed three people in China in 1992.[14] Strontium-90 is used in industrial heating devices is a by-product of uranium.[15] Two abandoned strontium-90 sources caused serious injury to three men in FSU Georgia in 1993.[16] The IAEA has cataloged more than 10,000 radiotherapy devices and over 12,000 industrial devices using these materials in its 134 member states.[17] However, over 100 of these member states have admitted to an insufficient capability to monitor all the sources, and many of the over 50 non-member states make very little attempt at tracking their radioactive material.[18]

The most cunning 4GW adversary may not even attempt to "obtain" radioactive material at all. Applying the 4GW tenet of using an enemy against himself, an adversary may transform a nuclear power station or radioactive storage facility into a radiological weapon.[19] United Airlines Flight 93 on September 11th may have been targeted at one of the three nuclear power stations in southern Pennsylvania—had the attack been successful, a Chernobyl-like radioactive plume would have probably resulted.[20] Nuclear reactor containment buildings are built to

withstand a relatively small explosive shock and are not engineered to protect against a worse case scenario.[21] A more plausible scenario is a fourth generation warrior using a truck bomb against a reactor or a radioactive material storage facility. There are 130 commercial nuclear reactors in the United States; each one has the potential to become a radiological weapon.[22] These power stations are predominately located in the densely populated northeast United States. While there is substantial security of at the nation's nuclear power stations, the 36 non-power reactors have markedly decrease security. These reactors are primary operated for research purposes and are located on university campuses. Maps displaying the location of the nuclear reactors in the United States are displayed on the next page:

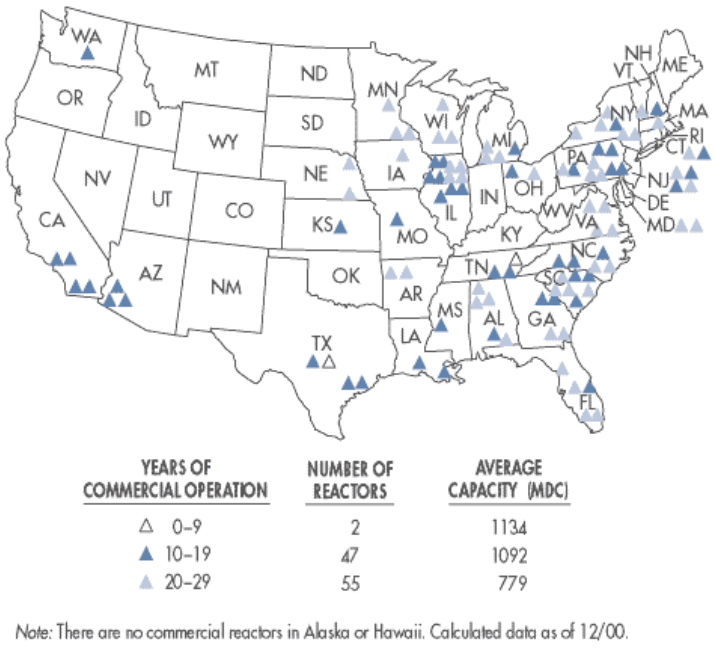

Figure 2. Nuclear Power Stations in the United States

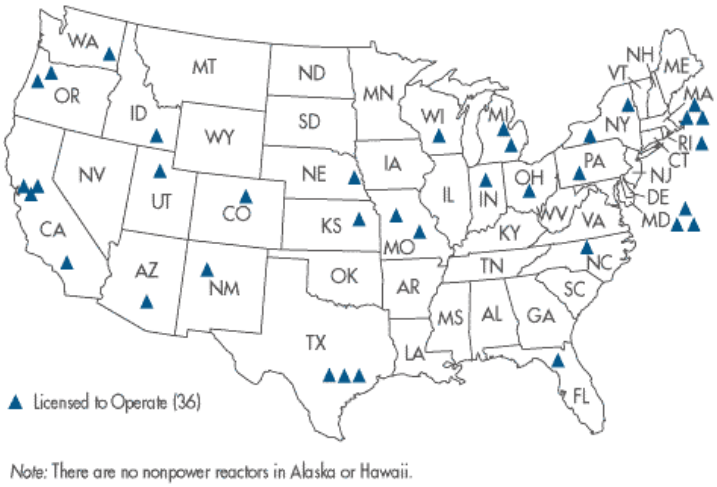

Figure 3. Non-Power Nuclear Reactors in the United States

An even simpler scenario would be to rig a shipment of radioactive waste with explosives and detonate it while transiting a populated area. Each of the 166 reactors ship their spent nuclear fuel to one of five storage sites across the United States, while the 35 nuclear fuel processing facilities ship radioactive material between themselves and to the reactor stations.[23] There are over 5000 shipments of non-defense related radioactive material a year in the United States under the National Transportation Program, which is jointly administered by US Department of Transportation, US Nuclear Regulatory Commission, Department of Energy and the US Postal Service.[24] Commercial radioactive material that would likely be used in the fabrication of radiological weapons is routinely shipped completely unguarded, while shipments of nuclear reactor fuel are minimally guarded. By law, the routing of these shipments is public knowledge.

From this analysis, it is clear that a 4GW adversary would encounter little resistance in obtaining radioactive material. The task of obtaining the requisite amount of radioactive material is simplified further still if the 4GW adversary has a state sponsor. Once the radiological weapons are fabricated, the 4GW foe must then determine the when, where and how the device

will be employed. By conducting a center of gravity analysis on the United States and determining the desired effects, a fourth generation warrior can glean how best to inflict an economically crippling radiological attack.

Notes

[1] *Inadequate Control of the World's Radioactive Sources,* IAEA [International Atomic Energy Agency] Press Release (Vienna, Austria: IAEA, 24 June 2002), 2.

[2] Richard J. Burk, *Radiation Risk in Perspective,* Health Physics Society Report (McClean Va.: Health Physics Society, 2001), 2.

[3] Ibid.

[4] Senate, *Nonproliferation Efforts in the Former Soviet Union: Hearings before the Committee on Foreign Relations,* 107th Cong., 2d sess., 23 April 2002, 3-8.

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[6] House, *Combating Terrorism: Preventing Nuclear Terrorism: Hearings before the Subcommittee on National Security and Veteran's Affairs of the Committee on Government Reform,* 107th Cong., 1st sess., 24 September 2002, 3.

[7] Senate, *Nuclear Nonproliferation and Nuclear Smuggling: Hearings before the Subcommittee on Emerging Threats and Capabilities of the Committee on Armed Services,* 107th Cong., 2d sess., 30 July 2002, 5.

[8] Lewis M. Simons, "Weapons of Mass Destruction: An Ominous New Chapter Opens on the Twentieth Century's Ugliest Legacy," *National Geographic,* November 2002, 17.

[9] *Medical Management of Radiological Casualties,* Armed Forces Radiobiology Research Institute Report (Bethesda, Md.: Military Medicine Operations Office, December 1999), 121.

[10] Michael A. Levy and Henry C. Kelly, "Weapons of Mass Disruption," *Scientific American,* November 2002, 78.

[11] "Possibility of Dirty Bomb in Nigerian Theft," *Washington Post,* 6 March 2003, 1, on-line, Internet, 12 April 2003, available from http://washingtonpost.com/wp-dyn/articles/A49840-2003March6.html.

[12] *Medical Management of Radiological Casualties,* 119.

[13] Ibid., 123.

[14] *Inadequate Control of the World's Radioactive Sources*, 4.

[15] *Medical Management of Radiological Casualties*, 135.

[16] *Inadequate Control of the World's Radioactive Sources*, 2.

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[19] Gavin Cameron, "Nuclear Terrorism: Reactors and Radiological Attacks after September 11th," (paper presented at an IAEA meeting, Salford, United Kingdom, 11 February 2001, 2.

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[20] Ibid., 4.

[21] Ibid., 6.

[22] "Operating Reactors," *NCR [Nuclear Regulatory Commission]*, 27 September 2002, n.p., on-line, Internet, 3 April 2003, available from http://www.nrc.gov/reactors/operating.html.

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Part 4

Center of Gravity Analysis and Effects-Based Operations

The important measure is not the targets destroyed but rather the effect on the enemy's capabilities and actions

--Brig Gen David Deptula

Methodology for Center of Gravity Identification

The success of the 4GW adversary rests heavily on center of gravity identification. Much has been written regarding centers of gravity, starting with Clausewitz and extending to the present day. For clarity, this analysis will define the center of gravity as a primary source or agent of moral and physical strength.[1] Of note, multiple centers of gravity are often interdependent, which is the case in the US economy.[2] The centers of gravity or their components must be targeted with some specific purpose, or effect, in mind. Effects-based targeting or effects-based operations are beginning to gain favor in the US military, and it is logical to assume that any 4GW foe would also apply this methodology. The September 11th terrorist obviously accomplished at least a cursory center of gravity analysis and chose targets that would produce the most detrimental effects on American economic power and prestige. Determining a center of gravity of the US economy is a daunting but essential task if an enemy wishes to "defeat" America.

Cursory Center of Gravity Analysis of the US Economy

The shear size and complexity of the America's economy certainly would tend to indicate that a precise center of gravity determination is difficult. When confronting a complex system, a rational method is to break the system down into its constituent parts. An overly simple but useful model breaks the economy into three parts: people, material, and processes. People supply the labor, intellectual capital and ultimately are the consumer of the goods and services. People also inject the "profit motive" that fuses the system together—the desire to sustain, change, build, improve, or perhaps, to destroy. Raw and finished materials fuel the system. The processes span the gamut from producing the power to manufacture the goods and services to transporting those goods and services to the consumer, with many intermediate and supporting steps. These three parts reasonably fit the definition as centers of gravity, for each is a vital "hub" of the economy. Each of these centers of gravity has unique critical capabilities that the fourth generation warrior must consider when attacking to achieve a desired effect.

Critical Capabilities

Critical capabilities are "the inherent abilities which enable a center of gravity to function as such."[3] For people, the critical capability is the ability to work, think, consume and want. The critical capability for material is simply to exist and be available. The processes of the economy are similar to that of the materials and the people. In short, the processes must be available, supportable, and functional. A fourth generation warrior may discern that targeting a center of gravity's critical capability may be simpler than targeting the center of gravity directly. For instance, a fourth generation warrior would find it impossible to target all 260 million people in United States, but targeting the desire to "want and consume" or to "work" may be achievable. Closely linked to a center of gravity's critical capabilities are the critical requirements.

Critical Requirements

Critical requirement are the essential conditions, resources and means required for a critical capability to be "fully operative."[4] For people to be "fully operative" they require fulfillment of certain requirements, perhaps best delineated by Maslow's first three levels in his renowned hierarchy of needs. Humans unequivocally require fulfillment of baseline *physiological* needs of air, food, water, and sleep.[5] The next level on Maslow's hierarchy is *safety* needs, which are mainly psychological, but also entail establishing security, stability and consistency.[6] Maslow's third tier, *love* needs, focuses on the human desire to belong to groups and feel accepted by others.[7]

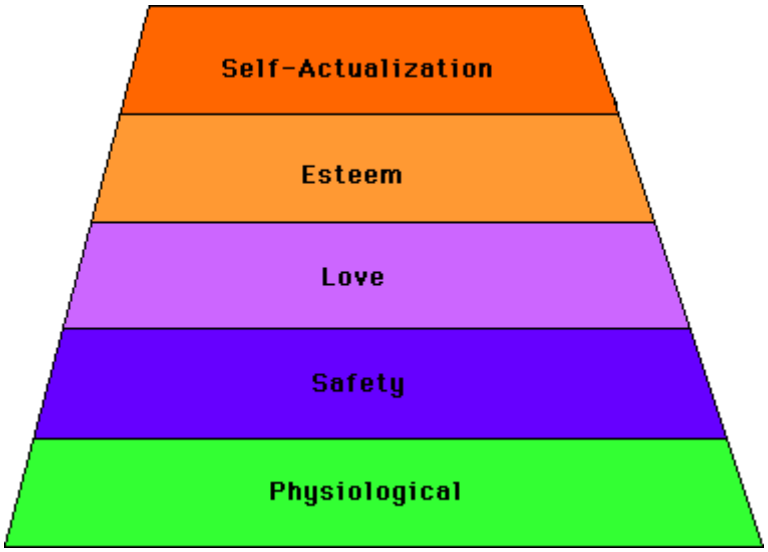


Figure 4. Maslow's Hierarchy of Needs

The critical requirements for material are to be available, either in a raw or finished form, transportable to the appropriate location, and/or transformable into the appropriate physical state. Nearly every process in the economy has the critical requirement of people to make it work, and most require material as well. In addition, processes have the critical requirement of some type of network and command and control. For example, the rail transportation process requires people to load and operate trains, fuel to power the engines, a network of railways to facilitate

the movement, and a command and control process to ensure the train and goods arrive safely at the appropriate destination.

People once again have the predominate amount of critical requirements. If a fourth generation warrior can successfully interdict or adversely affect these critical requirements, then the center of gravity will cease to function as such. It logically follows that the center of gravity with the most critical requirements will also possess the lion's share of critical vulnerabilities.

Critical Vulnerabilities

Critical vulnerabilities are weaknesses that may be exploited to "undermine, neutralize and/or defeat an enemy center of gravity."[8] People are both literally and figuratively the "softest" target of the three economic centers of gravity. People have the preponderance of critical requirements, most of which are also critical vulnerabilities targetable by the fourth generation warrior. A radiological weapon could contaminate food and water, interrupt consistency, and even affect the human desire for acceptance. The human psyche may be the most exploitable critical vulnerability to radiological weapons. It would be impossible for fourth generation warriors to contaminate all the food and water in the United States, but they could affect nearly every American's attitudes and behavior.

Material's critical vulnerability is that it has mass, and is therefore can be contaminated. Nearly all material must at some point be transported, transformed or constructed. Virtually all materials require humans to either acquire it, as in mining operations, or transform it, as in manufacturing finished goods.

The critical vulnerabilities of processes are that they require humans and material to operate. The command and control of processes is also targetable by 4GW adversaries, as well as key nodes in the networks. For example, ports are key nodes in the shipping process—if the

port is closed, the process will either cease or operate sub-optimally. The most critical vulnerability of our economic processes is the dependence on humans, who in turn possess a myriad of vulnerabilities. From this analysis, two of the three centers of gravity, material and processes, require people to be "fully operative." The center of gravity interdependence allows the fourth generation adversary to cripple the entire economic system by primarily targeting to achieve specific effects on the human component of the economy.

Table 4. Cursory Center of Gravity Analysis of the US Economy

Economic Center Of Gravity	***Critical Capability***	***Critical Requirement***	***Critical Vulnerability***
People	Work, Think, Consume and Want	Air, Food, Water, Shelter, Stability, Love	Air, Food, Water, Shelter, Stability, Psyche
Material	Exist, Available	Available, Transportable, Transformable	Mass, People
Processes	Available, Supportable, Functional	People, Material, Network, Command and Control	People, Material, Nodes, Command and Control

Sources: Dr Joe Strange, "Identify Centers of Gravity and Their Critical Vulnerabilities," in *Air Command and Staff College Air and Space Operations Coursebook*, eds. Maj. Mike Dilda et al. (Maxwell AFB, Ala.: ACSC, 2003) 400-401[9]; and author's own analysis.

Effects-Based Operations

Effects-based operations center on targeting or engaging an adversary's key capabilities, requirements or vulnerabilities in the most efficient manner to produce a specific effect.[10] Effects-based targeting is most effective if accomplished in parallel, meaning that the attacks should be timed simultaneously to achieve cascading effects.[11] The two broad categories of effects are *direct* and *indirect*.[12] Direct effects are first order effects that results from the actions

with no intervening effect or mechanism between act and outcome.[13] Indirect effects are second or higher order effects that are created though an "intermediate effect or mechanism to produce the final outcome."[14] A subcategory of indirect effects are *cascading* effects and *cumulative* effects. Cascading effects "ripple through the enemy system" while cumulative effects are the "aggregate of many direct and indirect impacts on a system."[15] Effects can also be categorized into physical, systemic, and psychological. The physical effect is aimed at the physical neutralization of the target.[16] A systemic effect is aimed at "disrupting the functions of a specific system or systems."[17] Psychological effects "occur in the adversary's mind and require an indirect approach as there is no material basis to directly target."[18]

Radiological weapons are multifaceted when viewed from an effects-based operations perspective. The direct, physical effects of a radiological attack results in comparatively little damage to material, people, or processes. The radiation from the weapon would cause potentially tremendous indirect, systematic and psychological effects due to contamination and "area denial." The indirect effects could cascade throughout the entire economy, thereby transforming into a systematic effect. The cumulative effect of multiple radiological attacks cascading through various segments of the economy could prove debilitating. The center of gravity most vulnerable to the radiological weapons is the people, and the weapon's effect that could be most damaging is fear.

Notes

[1] Dr. Joe Strange, "Identify Centers of Gravity and Their Critical Vulnerabilities." In *Air Command and Staff College Air and Space Operations* Coursebook. eds. Maj Mike Dilda et al. (Maxwell AFB, Ala.: ACSC, 2003), 400.

[2] Ibid.

[3] Ibid.

[4] Ibid.

[5] Robert Gwynne, "Maslow's Hierarchy of Needs," 1997, 1, on-line, Internet, 11 March 2003, available from http://web.utk.edu/~gwynne/maslow.htm.

[6] Ibid.

[7] Ibid.

[8] Strange, 400.

[9] Ibid.

[10] Brig Gen David A. Deptula, "Firing for Effects," *Air Force Magazine*, April, 2001, 48.

[11] Ibid.

[12]Jay M. Kreighbaum, "Force Application Planning: A System-and-Effects-Based Approach" (master's thesis, School of Advanced Airpower Studies, 1998), 75.

[13] Ibid.

[14] Ibid., 75-76.

[15] "Effects," *Air Force Doctrine Center Doctrine Watch 14,* 16 February 2001, n.p., on-line, Internet, 11 March 2003, available from https://www.doctrine.af.mil/left.asp?Color=6F0000 &StopRollover=DoctrineWatch&able.html.

[16] T.W. Beagle, "Effects-Based Targeting: Another Empty Promise," In *Air Command and Staff College Air and Space Operations* Coursebook. eds. Maj Mike Dilda et al. (Maxwell AFB, Ala.: ACSC, 2003),78.

[17] Ibid., 70-72.

[18] Ibid.

Part 5

The Strategic Effect of Fear on the Economy

The psychosocial effects of such contamination would be maximal, as we know from Three Mile Island, Chernobyl, and other incidents.

--Steven E. Koonin
Provost, California Institute of Technology

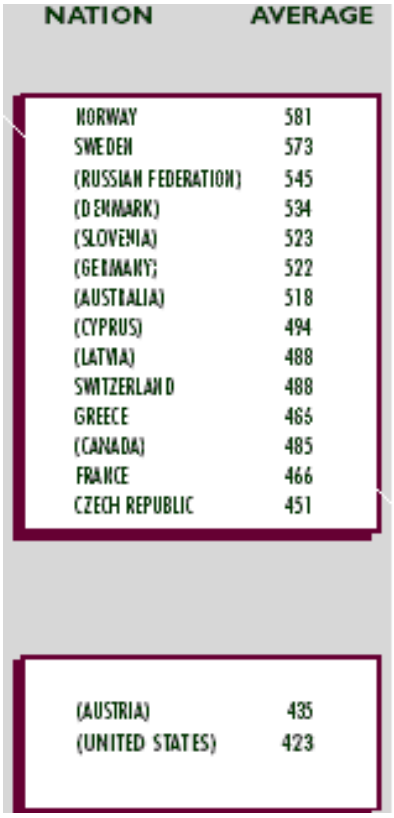
Fear in the Fourth Generation

The primary center of gravity of the US economic system is people. The fourth generation warrior endeavoring to achieve a strategic effect of incapacitating the US economy would naturally select the most vulnerable target to achieve those results. The fourth generation warrior would only need to create the requisite amount of fear and let the ensuring media hysteria propagate the trepidation to every man, women and child. The United States is ripe with recent examples of the media spread and media-induced fear. The shark attacks of the summer of 2001; the anthrax letters, the West Nile virus and the D.C. snipers are the most poignant examples of media hysteria fueling fear. The other vital ingredient is the nature of the target – the people. The September 11th attacks have caused many American to overreact to the slightest security threat. The February 13th 2003 Code Orange alert regarding a possible chemical or biological terrorist attack spawned a run on plastic wrap and duct tape, as people attempted to convert their homes into air-tight vessels. The people who Saran-wrapped their house did so

because of the anxiety produced from September 11th combined with their lack of understanding of the nature of the chemical or biological threat. The Orange Alert fiasco is a powerful portent of why a radiological attack would be so devastating.

People fear what they do not understand, and Americans as a group do not have a sound grasp on nature of radiation. In fact, American high school seniors scored dead last, compared to other industrialized and not-so-industrialized countries, on physics testing in 1999, and near the bottom of the industrialized world on math and science in general, as the table below reveals.[1]

Table 5. International Physics Test Results of 12th Grade Students



NATION	AVERAGE
NORWAY	581
SWEDEN	573
(RUSSIAN FEDERATION)	545
(DENMARK)	534
(SLOVENIA)	523
(GERMANY)	522
(AUSTRALIA)	518
(CYPRUS)	494
(LATVIA)	488
SWITZERLAND	488
GREECE	466
(CANADA)	485
FRANCE	466
CZECH REPUBLIC	451
(AUSTRIA)	435
(UNITED STATES)	423

Source: National Center for Education Statistics, *Pursuing Excellence: A study of US Twelfth-Grade Mathematics and Science Achievement in International Context* (Washington, D.C.: NCES, 1998), 7.[2]

People often confuse "radiological," a term which implies a wide range of nebulous but harmful effects, with "nuclear," which evokes images of Hiroshima-like mushroom clouds, vaporizing heat and radioactive fallout. The combination of a lack of basic understanding of radiation coupled with the 24-7 media frenzy following a parallel radiological attack could arguably create a paralyzing fear in the public. This fear would in turn affect people's behavior, especially in areas that have already been attacked. In this regard, our very conservative "safe exposure level criteria" would greatly increase the quarantine area.[3] The larger the contaminated area deemed uninhabitable for unprotected transit or occupation, the greater the economic impact. The ability to adequately decontaminate the radiation to meet the minimum safe standards would be laborious and expensive, while waiting for the radiation to naturally dissipate could take years, decade, centuries, or millennia. The fear factor would be artificially elevated by the confusion of five important variables: the degree of radioactivity of the material used in the radiological weapons, the amount of radioactive material used, the method of dispersal, the environmental conditions at the time of the blast and the weather effects on the dispersion of the radioactivity. "Experts" would speculate and disagree, on national TV, about the overall affect of these variables on the efficacy of the radiation contamination.

Radiation combined with 4GW attacks, akin in many respects to a terrorist attack, will evoke a powerful psychological response. The negative psychosocial responses to a radiological 'terrorist" event stem from the "open-ended" nature of the threat, the chronic state of alarm stemming from fear of radiation contamination, and the fact that "nuclear" events are the most dreaded of all human catastrophes.[4] Confusion and fear could certainly drive people to refuse to work in or transit through contaminated areas. Fear of further attacks could cause people to avoid likely targets, such as large cities and other economic hubs. Insurers would raise rates,

making profitable enterprises more difficult in areas likely to be attacked. Fear would keep consumers away from businesses; make recruiting employees more difficult and drive up operating expenses.

In short, the vastness and complexity of the economic system gives it some inherent resilience while simultaneously making it impossible to defend against attack. To overcome this resilience would require full participation of the human element. Bringing the US economy to recession levels would require the participation of the US consumer. Fortunately for our enemies, the average is US consumer's behavior is significantly influenced by fear.

Economic Impact of a Coordinated Radiological Attack

The $11 trillion economy of the United States is subject to natural downturns and upturns, but its resilience is product of its diversity, decentralization and complexity. As Su Won Son, chief economist at Wells-Fargo summarized "because our economy is so big and diversified, not only in terms of products but geography as well, to some extent, we have our own safety net built in."[5] The loss of any one "facility, institution, company, or component would likely be filled quickly by another."[6] Unfortunately, the same analysts who tout the resilience of the US economy also acknowledge that the potential Achilles heel is the "psyche of the American consumer, who's spending accounts for two-thirds of all US economic activity."[7] If a 4GW foe can successfully attack the psyche of the American consumer through fear, then the economy will be placed in peril—especially if this psychological attack is coupled with substantial economic impact resulting from evacuations, closings and cleanups of key economic centers due to radiological attack. There are precedents that fourth generation warriors could induce such a cataclysmic economic decline.

Evidence from Chernobyl, Goiania, Three-Mile Island, the Washington D.C. snipers, the shark attacks and the September 11th tragedy suggest it is possible to cripple an economy from disruption, denial and fear. In addition, the west coast longshoreman strike provides a poignant example of the sensitive dependence of the US economy on a few vital areas and functions.

Longshoreman's Strike

The short-lived longshoreman's strike in 2002 cost the economy an estimate $48.6 billion.[8] Closure of the west coast ports rippled through the local and national economy. Perishable good spoiled on the docks or in container vessels waiting unloading, while just-in-time supplies stagnated, causing local and national shortages. Trade with Asia largely came to a standstill. The US government recognizes that the major ports are critical to the US economy from both an import and export standpoint, and have begun to study this critical vulnerability.[9] A joint exercise sponsored by the office of Homeland Security posed a scenario of a dirty bomb smuggled into the port of Los Angeles, but not detonated. This single "theoretical" port closure caused a 92-day backlog and resulted in a loss of $58 billion in revenue.[10] Ports are certainly a critical vulnerability to the "process" center of gravity of the economy. New York City, apart from being a major port, is also the financial hub of the world.

September 11th Attacks

The cost of the September 11th attacks ranged between $90 and $105 billion and cascaded throughout the national and international economy.[11] This number does not account for the lost revenue resulting from a drop in tourism or associate job losses. The US airline industry has yet to recover, with some major carries only flying at 80% of their pre-September 11th levels. The airlines lost more than $33 billion in 2001 while laying-off 94,000 people.[12] The economy showed the largest one month drop in September 2001 in the leading economic indicators since

the 1991 Gulf War. Contributing to the economic woes were large swings in stock prices and options, rising insurance premiums, and reduced consumer spending.[13] Consumer confidence plunged to the lowest in a decade while October 2001 saw the highest one-month increase in unemployment in 21 years, with manufacturing losing 142,000 jobs; services losing 110,000 jobs and non-airline travel related industry losing 60,000 jobs—all in one month.[14] Over 625,000 jobs were lost in 2001 either directly or indirectly attributable to the cascading or cumulative effects of the September 11th attacks.[15] The economy is still languishing almost two years after the tragic event, and signs for a positive recovery are not yet evident—as of this writing, the stock market is at a five year low and decreasing. Monetary experts have noted that as devastating as the attacks were, the indirect effects may have the greatest impact due to the "sustained deterioration in consumer, corporate, and financial confidence."[16]

New York is an economic hub in every sense of the word; 7.1% of the American workforce is employed in the greater New York City metropolitan area, with the concentration of business and professional service jobs 87% higher than that of the general economy.[17] Although the World Trade Center attack was devastating, New York's financial district has largely returned to normal operations. Such would not be the case had each of the hijackers checked two suitcases each of containing 10kg of cesium-137. As was shown in Scheider's example, Manhattan could have been contaminated for up to the next 1000 years. When a city in Brazil did become contaminated with radioactive fallout, the economic and psychosocial results were telling.

Goiania, Brazil Radiological Incident

Evidence of the debilitating economic impact, albeit on a local scale, of radiological catastrophes already exists. The local economy of Goiania, Brazil was devastated when a single

radiotherapy device containing cesium-137 was cracked opened in 1987 by local junkyard scavengers. The city of 800,000 was plunged into an economic recession. This inadvertent radiological contamination had a relatively insignificant physical effect, killing four people and injuring 240 more. Several buildings were razed while 85 others were evacuated in the downtown area, a vital economic center to the region.[18] Most of the downtown area remained under quarantine for months while cleanup efforts slowly proceeded.

Although the quarantine of the downtown area had a definite impact on the local economy, the major contributor to the economic collapse was the psychological effect that rippled through the populace. The localized economic depression made a difficult life even tougher, inhibiting many families ability to provide for their physiological needs. The fear of radioactive contamination spurred a boycott of products from the Goiania region. Local health facilities were overwhelmed with people complaining of sickness, most of which were never exposed to the radiation.[19] Government response was slow and confused--this affected the safety needs of the locals. Many of the contaminated people were shunned by friends, neighbors, and family. This shunning extended to anybody who showed any signs of sickness, even if it was not related to the radiation.[20] This had a direct effect on their love needs and accentuated the psychological effects of the radiation exposure. The first three “hierarchy of needs" of the people of Goiania were adversely affected by real or imagined radiation. The systemic effect was to isolate the community economically, untimely leading to a collapse. The chief cause of the recession was not radiation, but fear, as research conducted in 1993 revealed.[21] The study investigated the stress and the psychological effects on the local population because of the incident. The research involved three groups: people who had been exposed, people who had not been exposed but lived nearby, and a control group. Both the exposed group and the

unexposed group living nearby both showed adverse behavioral effects, with the unexposed group showing anticipatory stress over the potential exposure to ionizing radiation.[22] The fear response is not limited to the relatively unindustrialized world of the Brazilian Amazon region, similar psychological results occurred here in the United States in 1979.

Three-Mile Island

Another radiological incident close to home was Three Mile Island nuclear power station. The accident came dangerously close to a core meltdown due to a series of human errors combined with a minor cooling malfunction.[23] Even though a negligible amount of radioactive contamination occurred, the manufacturing losses to the surrounding area totaled $6.3 million, $8.8 million in lost tourism ravenous, and $8.6 million in non-manufacturing losses, all in 1979 dollars.[24] The accident's greatest impact was to further instill a fear of radiation in the American public as well as a distrust of the government's response to radiological events. This fear and distrust are the primary reasons for the drastic slowdown in nuclear power plant construction during the 1980s and 1990s.[25] Although there was no toll in human lives, the psychological stress imposed on the local population was severe. Research into a group of residents confirmed that "exposure to radiation and toxic substances could have a powerful negative effect on the psychological and physical health, even when there has been no actual exposure."[26] Three Mile Island only set the stage for a far worse radiological accident in the USSR.

Chernobyl

The 1986 Chernobyl nuclear reactor accident killed nearly 500 people, contaminated 25,000 kilometers of land and forced over 340,000 people to permanently relocate.[27] Nine years after the accident, a total of 155,000 square kilometers were still contaminated with approximately one Curie per square kilometer of cesium-137 and strontium-90.[28] All food in

the region still must be imported, and even food deemed safe in the outlying regions is shunned for fear of contamination.[29] The people of the region are also shunned in a similar manner as the people in Goiania. People are often afraid to marry Chernobyl survivors for fear of radiation related birth defects or early death due to cancer.[30] Perhaps the statement by Dr. Richard Wilson, as Harvard University physics professor who studied Chernobyl, best encapsulated the problems confronting people recovering from a radiological incident we he stated that "the disease here is not radiation sickness. Except for children, the physical effects are not easy to measure. The truth is that the fear of Chernobyl has done much more damage than Chernobyl itself."[31] The radiation of Chernobyl posed a very real, albeit invisible, threat. The economic collapse of the region, although tragic, was at least justifiable due to the radiation. Such is not the case of the localized economic trauma felt by retailers in the Washington, D.C. area in 2002.

Snipers, Sharks and the Media

The regional economic impact of the serial killings by a pair of snipers, operating much in the same manner as classic fourth-generation warriors, has been "virtually unprecedented."[32] Area merchants witnessed a 25% reduction in retail sales during the height of the sniper scare.[33] The localized impact was staggering considering that during the two-week period, thirteen people where shot by the sniper, a fraction of the average of those killed in automobile accidents in the area during the same period. A similar event occurred in the summer of 2001 with an increase in shark attacks. While there was an increase in shark attacks compared to previous years, the chances of being killed by an alligator in Florida was greater than being eaten by a shark.[34] This fact did not keep the media from airing stories of shark attacks from every possible perspective. The causal link between these two events is the media. The fear evoked by the sharks and the snipers was fueled by media hysteria and not by any substantial risk.[35] This

media hysteria is a by-product of intense competition between the broadcast and cable networks along with the need to fill the TV screens 24 hours a day, seven days a week. Author Barry Glassner's book *The Culture of Fear: Why Americans Are Afraid of the Wrong Things* captures the essence of why the snipers and the sharks are so prevalent in our lives—that fear provokes action in the masses more than any other emotion.[36] Senior portfolio managers at Cambridge Asset Management, who were beleaguered by the media coverage during the sniper attacks and West Nile Virus scare, gave an even more poignant comment of the media's effect on fear and economy. The portfolio managers, Martin and Bart Siegel, lamented "the media's incessant negative, unproductive messages are creating the confusion, and negative sentiments, that are leading us to hysteria, and paralysis. They are draining our ability to respond coherently."[37]

By fusing data from the aftermath of the Longshoreman's strike, September 11th, D.C. sniper and shark attacks with the radiological incidents at Goiania, Three Mile Island and Chernobyl, it is quite possible that a coordinated parallel radiological attack could induce sufficient fear and damage to paralyze the US economy. What would be the likely targets of such an attack?

Scenario for a Crippling Economic Attack Using Radiological Weapons

Although the US economy could withstand virtually any neutralization of a single center or component, it may not fair so well if multiple economic hubs were targeted in parallel.[38] Using a parallel attack methodology, a 4GW could wreak havoc on the US economy by attacking the following targets with REDs: New York City, Washington D.C., Houston, Jacksonville, Mobile, Los Angeles, Chicago, San Francisco, San Diego, Seattle, Norfolk and Boston. The attacks on New York and Chicago would shut down the two largest stock exchanges and financial centers in the United States. The attack on Washington D.C. would paralyze the

government, to include the military if the Pentagon were hit. Neutralizing the west coast ports would halt much of our trade with Asia. The east coast port shutdown would devastate our trade with Europe. The gulf port shutdown will ravage our oil imports from the OPEC nations and our trade with South America and the Caribbean. Such an attack would have much the same economic impact as if the United States had been struck by "neutron bombs." All the buildings would be standing, and the people, although not dead, would be just as absent.

The 4GW adversaries could simultaneously attack the following targets with non-explosive RDDs: random water supplies, food storage areas and agricultural areas in the South and Midwest. This would create fear in rural America while simultaneously causing the public to doubt the safety of the food and water supply. The fourth generation warriors could realistically contaminate only a *negligible portion* of the food and water, but they could make most Americans fearful of *all* their food and water.

As was the case with the sharks and the snipers, the media would propagate the fear throughout the United States and the world. After the attacks, the fourth generation warrior would only have to sit idly by and watch the fear spread via our TVs, satellites, cell phones and Internet technology. The attack would disable the people, processes, and much of the material of our economy. The confluence of isolating the economic centers from functioning while simultaneously targeting the physiological, safety, and love needs could cause strategic economic paralysis.

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Notes

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Part 6

Conclusions

"People react to fear, not love; they don't teach that in Sunday school, but it's true"

--Richard Nixon

A 4GW adversary has the will, motive and means to obtain, fabricate and activate multiple radiological weapons in the United States. If the centers of gravity are correctly identified and targets are chosen carefully with the desired effects in mind, then the adversary could send the US economy into a state of strategic paralysis. Fear is the vital ingredient to a 4GW radiological attack. Although the physical effects of a coordinated radiological attack would be staggering, a crippling blow could only be dealt if the US economy collapses from within. That collapse would occur if the American consumer reduced spending significantly and the American worker was unable to be productive. The reduced spending and reduced productively could start a downward economic spiral similar to the depression of the 1930s.

There is no effective defense against such an attack, and the government is unprepared to respond adequately. Once the attack occurs, the effects will ripple throughout the United States and the globe, with the media feeding the flame of fear around the clock. Atop the economic losses, the government will be force to spend profusely in cleanup costs and increased security measures to ensure such an attack does not reoccur. The combination of backbreaking deficit

spending and economic stagnation would force the United States to withdraw from its present strategy of global engagement to "nurse the wounds" back home. The resulting economic decline would negatively affect a majority of the US population, causing a significant change in the American way of life and resulting in a de facto defeat of the United States.

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